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Adapting Global Service-Learning Project and Community Partnership Outcomes Using a "Tele-engineering" Approach in Response to the COVID-19 Pandemic

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Adapting Global Service-Learning Project and Community Partnership Outcomes Using a “Tele-engineering” Approach in Response to the COVID-19 Pandemic

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ADAPTING GLOBAL SERVICE-LEARNING PROJECT AND COMMUNITY PARTNERSHIP OUTCOMES USING A "TELE-ENGINEERING" APPROACH IN RESPONSE TO THE COVID-19 PANDEMIC

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STUDENT AUTHOR BIO SKETCHES

Christian Ley is a PhD candidate in environmental engineering at Purdue University. She has been affiliated with the Water Supply in Developing Countries (WSDC) course for three years and has traveled to the Dominican Republic to install drinking water systems and share WASH materials with the communities. In this article, she describes the relationship of the WSDC class with the communities in the DR and their revised strategies to working with the schools in the DR during the pandemic.

Danielle Angert is a senior in Environmental and Ecological Engineering at Purdue University, with a minor in Spanish. She has worked in drinking water quality research for the past year as an undergraduate research assistant. Next year, Danielle will attend the University of Texas at Austin to begin her master's degree in Civil and Environmental Engineering while continuing to research drinking water quality. She has been involved with the Water Supply in Developing Countries project for two semesters. Other ways Danielle has been involved with service-learning projects are through Habitat for Humanity and Purdue Student Sustainability Council.

Tessa Hudelson is a senior in chemistry at Purdue University. She has been working as a research assistant since her sophomore year in Dr. Linda Lee's research lab. She plans to pursue a career in chemistry and will be working with Inotiv after graduation in May. She has been involved with Water Supply in Developing Countries for two years, serving as the course leader and previously the secretary for the Water Supply team.

Jordan Harris is a junior with double majors in Brain and Behavioral Science and Spanish. She has previous and current research experience in public health and psychological science, and intends to pursue a career in public health research concerning underserved populations. It is her second semester in the Water Supply in Developing Countries class, and as the following article explains, it has been spent learning how the class can adapt its water safety and sustainability goals to better serve its partner communities in response to COVID-19.

ABSTRACT

The Water Supply in Developing Countries (WSDC) service-learning course at Purdue University has fostered a strong partnership with the La Vega region in the Dominican Republic since 2012. During this time, an interdisciplinary group of engineering and science students has helped design drinking water treatment systems and the group has developed water, sanitation, and health (WASH) education materials. These WASH education and water safety approaches often have been conducted in person in the past. However, with the state of the COVID-19 pandemic and the inability to travel in the fall and spring semesters of the 2020–2021 academic year, the students have been exploring (1) the impact of the pandemic on the community schools in the La Vega province, (2) the impact of the pandemic on the current water treatment systems, and (3) possible solutions to implement a "virtual installation" of a water treatment system at our newest partner school in the community of Desecho. The coronavirus pandemic has ushered in a new way that we may approach our service-learning experiences in the future. More specifically, in the future, it may be more effective to serve as a "virtual consulting firm" of engineers and consultants, rather than builders, for the implementation and design of the water treatment systems. In this way, we may facilitate a partnership that fosters community agency and solution-based approaches to technical issues are led by local community members.

INTRODUCTION

Global service-learning courses provide a unique, synergistic opportunity for students to learn and develop new skills required for their future careers, while also contributing to an international development project. The COVID-19 pandemic has significantly shifted the way that service-learning professors, students, and partner communities approach their development projects. More specifically, the shift to online learning, the inability to travel internationally, and the lack of a strong communication infrastructure has proved a considerable setback in the context of service-learning international development projects.

Water Supply in Developing Countries (WSDC) is an interdisciplinary service-learning course (EEE 595.017; CE 597.135; BIOL 595.074) that brings together students from engineering, the life sciences, economics, and many other disciplines for one common goal of delivering clean, safe drinking water for community schools in the La Vega province of the Dominican Republic (DR). Unsafe drinking water can result in diarrheal disease and is a major cause of morbidity in low-income areas, especially in children (Stanaway et al., 2018). Using our cross-disciplinary expertise, we have three main focuses: (1) to deliver and develop educational materials about water, sanitation, and health (WASH) for the teachers in the community schools, (2) to design and implement long-term sustainable drinking water treatment systems, and (3) to monitor the health outcomes and lifestyle changes that occur as a result of the public health education and engineering initiatives. Accordingly, the course has three separate teams to accomplish these goals: (1) communications team, (2) design team, and (3) monitoring, evaluation, and publication team.

In response to the travel restrictions, the students in our service-learning course have identified alternative methods to come out of the pandemic stronger and more impactful than before. First, since travel is not advised, the students are using their time on campus to develop and test a working model of the water treatment systems that are built in the Dominican Republic. Constructing the model system on campus serves a twofold purpose: (1) to teach the students how to design and construct a working water treatment system, and (2) to prepare the students for the system construction process that they will experience in country. Next, an alternative method of "tele-engineering" will potentially be employed to install the next water treatment system in the Desecho area. This means that we will work with the community virtually to install their next drinking water system. By shifting the role of system construction management, this may allow the community stakeholders to have more ownership of the water treatment systems. In this way, the students are still able to work toward the class learning objectives and aid the partner communities despite their inability to travel abroad.

DESCRIPTION

Community Demographics and Needs

In the Dominican Republic (DR), approximately 69% of the population lives in urban areas and 31% of the population lives in rural, undeveloped areas (WHO and UNICEF, 2012). Within the rural areas of the DR, only 47.4% of the population has access to chlorinated water systems (Abreu, 2005). The La Vega province of the Dominican Republic is largely rural and the primary sources of drinking water are bottled water and rainwater (Centro de Estudios Sociales y Demográficos [CESDEM], 2007). Our team has been collaborating with the following communities in the La Vega province (population 394,205: 2010 Census): Las Canas, Los Peladeros, El Mamey, La Torre, and Desecho. Surface water in the area is increasingly contaminated with agricultural runoff and biological wastes as the population grows and very little sewage is treated before flowing into streams and unlined pits. In 2013, the class members conducted a survey of the Las Canas area and discovered that the primary drinking water sources changed by the season. In the rainy season, rainwater (51%) and bottled water (40%) were the main water sources, whereas in the dry season, rainwater (36%), bottled water (38%), and protected dug boreholes (14%) were the main water sources (Alwang et al., 2017). While the La Vega province is serviced by a local utility, the provision of water from local water trucks is often expensive for the schools and the water quality often degrades in transport. Thus, the La Vega community schools are challenged with issues of both water quality and affordability. Since the rural areas have very little access to disinfected drinking water, the overarching goal of the WSDC program is to provide community-sustained drinking water treatment systems for community schools in the rural La Vega province of the Dominican Republic (DR), and ultimately to improve the health and well-being of the community members there.

Communications, Entrepreneurship, and WASH Education

The communications team aims to develop WASH education materials and maintains communication with key community partners throughout the academic year. More specifically, the communications team serves as a communication link between the partner community members and the other WSDC teams. Reaching beyond the students at the schools, the communications team also develops WASH education materials that the students can bring home for their parents to learn about proper hygiene and drinking water safety. Globally, WASH materials are developed with the following objectives: (1) to reduce diarrheal disease and waterborne infections, (2) to improve school enrollment and attendance, and (3) to influence the parents and siblings of the students who received the WASH education materials (McMichael, 2019). When the class visits the community, they deliver WASH education materials and consult with the school teachers about the educational outcomes to assess impacts of the WASH education delivery.

Design and Implementation

The design team focuses on completing all theoretical and technical groundwork for implementation of water treatment systems. After spending several years communicating with the first partner community, Las Canas, the pilot water treatment system was installed in 2014. After multiple designs in Las Canas, our team designed and helped the community install water treatment systems in the communities of Los Peladeros in 2017, El Mamey in 2018, followed by La Torre in 2019. The descriptions of each water treatment system can be found in Table 1. Moving forward, the design team is now focusing on improving system design, enhancing maintenance protocols, and implementing new systems in the La Vega province. In order to ensure the longevity of the drinking water treatment systems, we have developed manuals and videos to act as a guide for maintenance and troubleshooting for the systems.

Monitoring, Evaluation, and Publication (MEP)

The main focus of MEP is to evaluate the effectiveness of the WASH education delivery and water treatment systems. This information curated by MEP is made available to the public via publications and presentations. In the past, MEP has worked to survey the communities about their attitudes and health outcomes following the implementation of educational and water

Table 1. Description of Community School Water Treatment Systems

Year Installed	Community System	Number of Students	Description of Components†
2013–2014	Las Canas	243	Sand filter, hollow fiber filter, Zimba auto-chlorinator
May 2017	Los Peladeros	230	Cartridge filters, UV disinfection, Zimba auto-chlorinator
May 2018	El Mamey	121	Sand filter, cartridge filters, UV disinfection, Zimba auto-chlorinator
May 2019	La Torre	261	Sand filter, cartridge filters, UV disinfection, Zimba auto-chlorinator
(2021*)	Desecho	123	*System is expected to be built in 2021

†Images of systems are included in the appendix (Figure A-1, Figure A-2, and Figure A-3).

safety measures for the communities. Through an iterative process of community surveys and education, this team is able to measure the successes and failures of the individual educational and communication practices.

Proposed Virtual Installation

During the 2020–2021 academic year, the WSDC design team has been working to construct a pilot-scale water treatment system (Figure 1) that has water treatment components similar to those installed in our community partner schools. Constructing the water treatment system (Figure 2) on campus has a twofold purpose: (1) to teach the Purdue University graduate and undergraduate students how to design and install a system with the proper treatment unit operations, and (2) to serve as a model for the virtual installation videos that could be used in the future to help the communities install their own water treatment systems.

While the students have been constructing the model system, they have been learning about the system parts and purposes along the way (Figure 2). For instance,

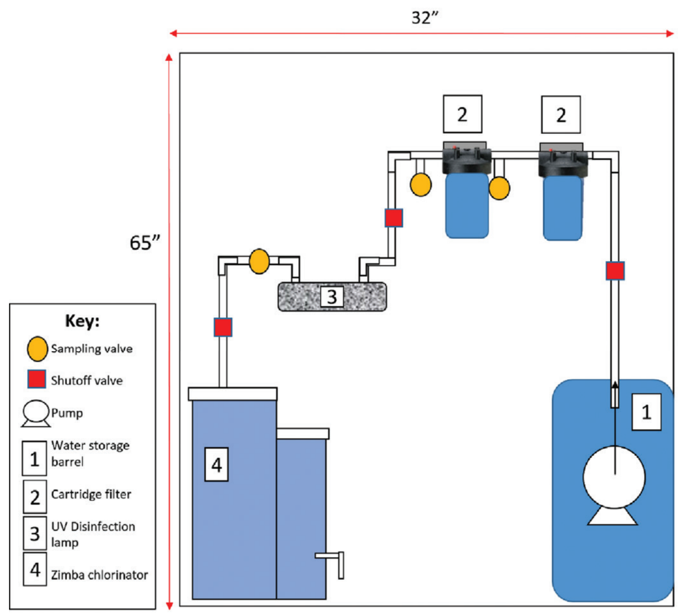

Figure 1. Schematic of rainwater treatment system model built by WSDC students.

Figure 2. WSDC students beginning construction of model water testing system.

they have learned about selecting the proper cartridge filters to remove sediment from the drinking water and how to install pipes and fittings. During the construction process, pictures and videos will be used to capture the individual steps of the construction process. Following the completion of the model system, a video will be compiled and translated into Spanish to be shared with the communities. We will include a series of videos in the virtual installation that we will share with the community partners, so that they will be able to construct the systems and follow along with the videos.

COMMUNITY IMPACT

Impact of COVID-19 on the Community Schools

The COVID-19 pandemic has disproportionately affected low- and middle-income countries (LMIC). LMIC areas are often overcrowded and "social distancing" may be difficult to maintain, thus many schools in LMIC areas have remained primarily virtual since the pandemic began (Donnelly & Patrinos, 2020). Attending school virtually impacts the quality of education, and the interruption in schooling may also reduce student access to clean drinking water and government-subsidized food when school is not in session (Zar et al., 2020) there are growing concerns about the risk of coronavirus disease (COVID-19). In the fall semester of 2020, the WSDC communications team contacted each of the four current partner communities and asked them questions about the state of the schools' operations in response to the COVID-19 pandemic. The communications with the school principals aimed to determine if students were attending the school and if the water treatment systems were in operation. Each of the four schools had ceased to be in session since March 2020 when the COVID-19 cases increased significantly. In addition, the schools have all been operating virtually until at least April 2021. As a result, only the teachers and the night watchmen had been on the school premises during this shutdown.

Implications for Current Water Systems

Due to a lack of resources and continuity of knowledge sharing about system maintenance and troubleshooting, it has been difficult to ensure that each of the systems is being properly maintained during the pandemic. Lack of community presence at the schools and social distancing has created even greater difficulty in ensuring system maintenance. During recent conversations with the communities, it was revealed that none of the water treatment systems have been used since March 2020, when the schools were last in operation. While the water treatment systems have been unused during the pandemic, it is likely that increased microbial growth and odors may develop in the systems because the students have been out of the schools for over a year (March 2020–April 2021). In drinking water plumbing, it is common for opportunistic pathogens to proliferate within pipes during extended periods of stagnation (Zlatanović et al., 2017). The pandemic has started to change our way of thinking about how we should approach service-learning and how we can utilize our engineering expertise virtually to make a more substantial impact.

Impact of COVID-19 on Class Trajectory

With the travel restrictions imposed by the global coronavirus pandemic, the WSDC class was not able to travel and install the fifth drinking water treatment system in the academic year 2020–2021. Given the inability to travel, the group has been planning for alternative methods to maintain a working relationship with the community by developing WASH education materials and planning alternative guidance materials for the installation and construction of the water treatment systems.

Current WASH educational materials that have been developed for this course include lessons on how pathogens spread, the importance of handwashing, how water affects the body, and lessons about how water is treated and disinfected. The educational materials are primarily delivered in person at this point, not through a video platform. However, the development of videos for the delivery of WASH education may be useful in the future so that the materials can be utilized at any time, not just when the WSDC service-learning students are in country. Furthermore, the community members have expressed interest in video-based water treatment system manuals, thus, a video-based approach for WASH education may be beneficial as well.

Plan of Action for Future Systems—"Tele-Engineering"

In the international development and health care context, a new framework called "telehealth" is being adopted to provide diagnosis and treatment using telecommunications for patients in remote and LMIC communities. Telehealth has been defined as "delivery of health care services by health care professionals using information and communication technologies for the exchange of information for diagnosis, treatment and prevention of disease and injuries, research and evaluation" (Combi et al., 2016). Technological advances and widespread

Internet access has allowed innovations in the delivery of telehealth care in low-income areas where travel may be difficult. Most recently, the pandemic has inspired health care facilities worldwide to include telehealth as a way to make health care more accessible. Inspired by this trend in rural health care, our class is planning to shift toward using a "tele-engineering" approach while international travel is discouraged.

This "tele-engineering" approach may solve a host of issues that are common to service-learning international development projects. First, many student-led projects in the past have installed water treatment systems or other health-related intervention with no follow-up to ensure the success of the project. In response to this phenomenon, many international development groups require service-learning student groups to commit to a multiyear partnership to keep in contact with the community and ensure that the design project is still in operation and is working well. In keeping with this multiyear commitment, a "tele-engineering" approach could greatly help with keeping the WSDC drinking water treatment systems in proper working order. Accordingly, the community leaders could contact the WSDC student group via video messaging immediately, whenever the schools have an issue with the water treatment system.

Next and most importantly, it is an important practice in international development projects to foster a sense of independence and self-sufficiency in the community, with respect to the water treatment system operation. By shifting toward a remote and virtual service-learning approach, we may be able to cultivate a more independent community that is fully capable of cleaning the systems and replacing system components on a regular basis. Finally, in the present state of the global pandemic, it is not advisable to travel abroad, so it makes practical sense to propose a virtual "tele-engineering" approach to install the fifth water treatment system in Desecho.

Relationship between the Model System and the "Tele-Engineering" Approach

As previously mentioned, the pilot-scale water treatment system serves the purpose of both aiding student understanding of how to design and construct a functional water treatment system and as a means to assist our community partners in the DR with system installation. Pictures and videos are currently being captured as the design committee builds the model system. We plan to combine these into a step-by-step cohesive video, potentially as a slideshow with voiceover, to visually represent the process of constructing a water treatment system. Further, certain techniques such as how to seal pipes with pipe cement will be recorded and shared with community partners in the DR. It is expected that the combination of written instructions and a visual representation will aid comprehension of this technical process.

Another possible outcome of the model system is being explored at the time of writing this paper. If the system can be installed outdoors in a similar environment to what is experienced in the DR (i.e., summer months in Indiana), then we can troubleshoot potential issues that may arise with the systems. For example, the team will learn how to clean spent cartridge filters, or how to refill the Zimba with new chlorine. Typically, an operating manual is created for each system, outlining an introduction to the system, system components, and water quality testing methods and parameters. These manuals are developed as documents and translated into Spanish to be shared with our partners in the DR. The model system provides the WSDC team with an opportunity to adapt this print manual into a video and to assist with problems in real time through Web-based communications platforms.

Community Feedback and Assessment of Virtual Communication and System Installation

After the community partner has installed their water treatment system with the aid of the video, the WSDC team will communicate with the community about their experience with the installation process. We will ask them about their successes and failures in the construction process, and they will provide feedback about what could be changed in the installation videos. The months following the installation are critical for the long-term success of the system. Thus, our group will maintain regular contact with the community, and we will ask them to inform us when maintenance issues arise. In response to their maintenance issues, we will either respond with the solution by sending them an informational video about how to fix the issue or provide live maintenance guidance over a video conferencing platform.

Regular communications will be kept with the community to determine how well the systems are performing. During these conversations, the water treatment systems will be assessed to determine if the systems are in use and the individual unit operations (filters, ultraviolet lamps, auto-chlorinator, etc.) are functioning properly. Additionally, each of the schools has water testing equipment with which they can test the water quality (chlorine, total dissolved solids, compartment bag tests for *E. coli* testing). As a measure of water treatment performance, this data can be readily collected by the system operators and shared with the students in the class.

Another way the virtual communication will be evaluated is through partnership with the MEP committee to design and implement surveys. MEP routinely surveys community members in the DR for a variety of reasons, such as understanding water taste preferences or to assess a baseline understanding of WASH practices. Thus, by working with the MEP committee, the design team can both understand the efficacy of a virtual design manual and assess community opinions about whether virtual installations should be continued once travel restrictions are lifted.

STUDENT IMPACT: SOLUTION AND ADAPTATION

In response to the COVID-19 pandemic, the students in the WSDC course have learned a variety of lessons that will ultimately help them in their future careers and community outreach activities. These lessons are related to flexibility in class communications, adaptability of class learning outcomes, and valuable engineering design experience. The first lesson learned in the pandemic is that of flexibility. When the pandemic first began, there was a shift from in-person learning to a virtual meeting format. With the travel restrictions, the students were faced with the challenge of how to keep making progress with the treatment systems' maintenance and new installations without being able to travel. The students developed the idea of constructing a water treatment system on campus with the dual purpose of teaching the WSDC students how to construct the systems while also developing an instructional video that can be used to teach the community partners how to build their own water treatment systems.

The format change in system installation from an in-person installation to a virtual installation is also beneficial for student learning outcomes. With the virtual format, the WSDC students are learning how to configure plumbing and how to install the filtration and disinfection units. Prior to the pandemic, these engineering and health sciences students had not gained any hands-on experience with constructing water treatment systems on campus. The construction of the campus water treatment system will be a kinesthetic learning tool that future generations of the class will be able to use to learn valuable engineering troubleshooting skills. More specifically, by constructing a system similar to the ones used in country, the students will be able to learn about common issues with the systems that can be translated to knowledge sharing if and when issues arise with the systems in the DR.

Specific tasks we plan to do differently to improve the experience moving forward are finalizing the location of the pilot system and increasing frequency of construction. The two possible locations have different needs, with one being a small farm with food crops, and the other being a green roof on a large office-style building. By finalizing the location, we can better design the system to not only meet our needs and those of our community members in the DR, but also benefit the recipient of the model system by providing free, potable water. Finally, with the current hybrid education system, construction of the pilot system isn't progressing as fast as it could during a typical year. It is our hope that next semester, we can finalize construction with more routine build days, once social distancing guidelines have eased and more students will be present on campus.

CONCLUSION

The Water Supply in Developing Countries (WSDC) service-learning course at Purdue University has been faced with technical challenges during the COVID-19 pandemic. Our interdisciplinary group of engineering and science students has learned to design drinking water treatment systems and the group has developed water, sanitation, and health (WASH) education materials that can be delivered virtually to our partner communities. With the state of the COVID-19 pandemic and the inability to travel in the 2020–2021 academic year, the students have realized the impact of the pandemic on the community schools in the La Vega region and the impact of the pandemic on the current water treatment systems. Reciprocity or mutual benefits to the partner community and the students can be further enhanced by increasing the frequency and breadth of communications.

In light of the pandemic, the students have unearthed possible solutions to implement a "virtual installation" of a water treatment system at our newest partner school. The pandemic has ushered in a new way that we may approach our service-learning experiences in the future. More specifically, in the future, it may be more effective to serve as a "virtual consulting firm" of engineers and scientists, rather than builders, for the implementation and design of the water treatment systems. In this way, we may facilitate a mutual and reciprocal partnership over time that fosters student creativity and design experience for the students, as well as agency and independence for the partner community with regard to system design, use, and maintenance.

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APPENDIX

Figure A-1. Rainwater treatment systems at schools in Las Canas (2014) and Los Peladeros (2017).

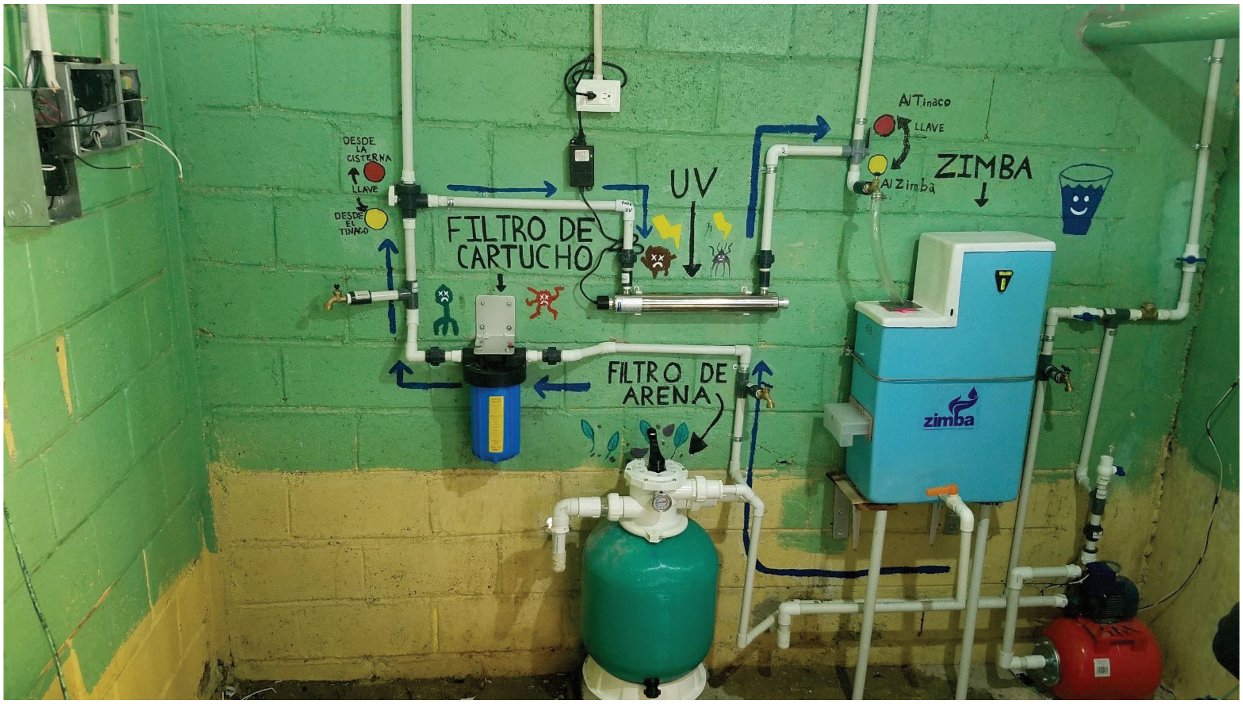

Figure A-2. Rainwater treatment systems at the school in El Mamey (2018).

Figure A-3. The rainwater treatment systems at the school in La Torre (2019).